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Biological Research Section
1984 Annual Report

Report No 85-173-K

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ABSTRACT

The activities of the Biological Research Section during 1984 are reviewed. Major efforts planned for 1985 are identified.

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TO Mr. F.J. Kee
Director of Research

BIOLOGICAL RESEARCH SECTION
1984 ANNUAL REPORT

INTRODUCTION

The Biological Research Section (BRS), of the Chemical Research Department, is a research unit headquartered in Building KD of the Kipling Complex at 800 Kipling Ave, Toronto. The Section is part of the Ontario Hydro Research Division.

The Biological Research Section is involved in providing a research service and carrying out scientific investigations in biological areas to meet Ontario Hydro's planning and operational needs.

As of December 1984, the Section was still administratively organized to meet the corporate strategy of 1978, which was based primarily on supply activities. To meet this strategy, the Section sought to provide extensive capability for long-term environmental surveys, studies in support of station licensing and design of intake and discharge structures, short-term studies in support of station operation, and carry out anticipatory studies in future areas of need. The organization consisted of three units: the Field Oriented Unit whose function was to carry out the required pre- and post-operational biological surveys at generating stations, and support the rest of the section by maintaining the necessary field capability for other studies; the Resources and Services Unit whose function was to maintain the laboratory capability required for the section, provide a taxonomic service, and carry out laboratory tests, bioassays, short-term studies, and the Fundamental Research Unit whose function was to initiate and carry out studies exploring biological concepts which will create opportunities for the Corporation.

Overlying the administrative organization and cutting across the units were a series of major program areas with discrete goals and timetables, and technically managed by an individual who has the responsibility of keeping the work focused. The purpose of this overlay is to ensure that the most suitable expertise can rapidly be brought to bear on a project regardless of the administrative unit. Areas which were managed in this fashion in 1984 were: Pre- and Post-operational Aquatic Surveys, Radionuclide Program, Vegetation Control, Capitalized Once

Through Cooling and Contract Impingement Studies. Other projects were managed on an individual basis.

In addition to the studies reviewed below, the section sought to monitor advances in the following areas: in acid effects on forests, remote sensing techniques in environmental monitoring, and biological environmental effect.

A staff list is presented in Appendix A, reports issued and their respective sources of funding in Appendix B, publications in Appendix C, papers presented in Appendix D, and external contracts in Appendix E.

1984-1985 WORK PROGRAM AND ACCOMPLISHMENTS

Pre- and Post-Operational Aquatic Surveys

These studies are carried out as requested by Design and Development in partial compliance with the provincial environmental regulatory agencies as part of the licensing process.

The objective of these studies is to determine through, an extensive sampling program, the effects, if any, of the construction and operation of new generating stations on the aquatic environment. These studies generally consist of a pre-operational phase, usually three years long, during the construction of the station; an interim phase during the commissioning of the units at the station; and a post operational phase, usually three years, during full operation of the station.

During 1984 studies were carried out at Pickering NGS 'B', Bruce NGS 'B', Atikokan TGS and Darlington NGS. Three of the studies were in the interim phase: Pickering, Bruce, and Atikokan. Darlington was in the first year pre-operational phase.

There were few obvious effects of construction at the Great Lakes sites but several construction effects were evident at the inland station, Atikokan GS. Dewatering in Moose Lake and Snow Lake caused substantial alterations in water levels which resulted in changes in both composition and distribution of aquatic macrophytes along the shorelines, as well as changes in zooplankton composition. Damming across the Marmion North site resulted in a reduction of available walleye spawning bed at the location, while channelization of the Icy Lake outlet, although partially removing a walleye spawning bed location, also removed an obstacle to movement of Marmion Lake walleye to other spawning sites in Icy Lake.

Additional short-term supportive studies were carried out at these sites as warranted.

For 1985 pre- and post-operational studies are expected to continue at Darlington NGS, Pickering NGS 'B', Bruce NGS 'B', and Atikokan TGS.

A summary report of the environmental impact of industrialization of Long Point Bay, Lake Erie, will be prepared for the Nanticoke Environmental Committee.

Radionuclide Program

The purpose of the radiobiological work in the Biological Research Section is to maintain the biological capability necessary to support the Corporation's Nuclear Generation program. This is achieved by carrying out a series of investigations sponsored by the Canadian Fusion Fuels Technology Projects (CFFTP), the radiobiological program, and investigations into biotechnological means of tritium removal.

1984-

For CFFTP the effect of a number of soil variables on T_2 deposition in three soil types was determined in a series of laboratory investigations. It was concluded that soil water content, soil porosity and organic content, control the deposition of T_2. A preliminary statistical model to describe the process was constructed and some field verification was attempted. A conclusion of the investigation was that most T_2-->HTO conversion occurs in the upper few centimeters of soil and is bacteria-controlled.

The goal of the radiobiological program is to provide data which will enable the development of models describing the fate and behaviour of key CANDU releases to the atmospheric and aquatic environments. To date, two major components of Candu releases have been investigated, tritium and gamma emitters. The tritium portion of the program is in its third year, and has focused on uptake dynamics and movements in selected "typical" food chains. In 1984 tomatoes were exposed to HTO in air. The tissue-free water tritium (TFWT) in foliage rapidly equilibriated to air HTO levels. The organically-bound tritium (OBT) reached steady state much more slowly at about 45% of HTO in air (on a specific activity basis). Unlike foliage, fruit OBT/TFWT ratios ranged between 0.72 and 1.92 (ie. >unity); this was attributed to the transport of foliar photosynthate, as building blocks, to fruit where TFWT was comparatively tritium free. The uptake and desorption of HTO and tritiated food in young growing fish (trout) was studied. Fish fed tritiated diet slowly reached OBT tritium

specific activity levels 80% of diet, and fish exposed to HTO alone rapidly reached OBT levels of approximately 20% of medium HTO. These results suggest that 20% of the animal OBT contains exchangeable hydrogens which exchange rapidly with source tritium, while 80% are non exchangeable.

Results of fish and tomato HTO and tritiated food exposure studies, together with earlier crayfish and algal studies, demonstrate that the common assumption of the tritium specific activity model are valid, ie, receptor tritium specific activity is lower than source tritium. These results would also suggest that observations of ratios greater than unity for OBT/TFWT in field samples were likely due to temporal aspects of tritium dynamics rather than any potential for tritium enrichment within an organism.

The main focus of studies on gamma emitting radionuclides has been in determining their distribution in the Great Lakes. Through 1984 their distribution in sediments of the lakeshore, nearshore, and deep basins of Lake Ontario were determined. Less than 1% of the total radioactivity measured was from man-made sources: ^{137}Cs, ^{134}Cs, and ^{60}Co. As expected good correlation between organic content of the sediment and radionuclide concentration was found. Only ^{60}Co was source related in the immediate Pickering discharge.

The literature was reviewed to determine the potential application of biological catalysis for T_2 conversion to HTO. The ecology, occurrence, and biochemistry of microorganisms capable of enzymic catalysis were reviewed. Recommendations were made for further investigations.

1985-

In 1985 the work plan includes participation in studying the deposition of T_2 during a CFFTP-sponsored field release experiment. The overall purpose of the experiment is to validate present transport and deposition models. Further development of the preliminary T_2 deposition model is planned to insure its usefulness.

In the radiobiology program a study to measure potential OBT increases during litter decomposition in the presence of HT in air has been planned. The last stage of the HTO uptake dynamics covering HTO dynamics in mammals will be initiated early in the year.

The distribution of gamma emitters in Great Lakes sediments will continue with the emphasis being placed on tracing the sources of Co^{90} found in the deeper basins of Lake Ontario, and

determining the binding coefficients for Co and Cs radioisotopes in selected lake sediments.

Investigations into the application of biological catalysis for the removal of tritium are expected to continue, emphasis will be placed on setting up appropriate bacterial cultures, and establishing hydrogenase enzymology for selected microbes.

Vegetation Control

The primary goal of the vegetation control program is to obtain, through research, information which may create opportunities for more effective, efficient, and environmentally responsible means of controlling undesirable vegetation on both transmission and distribution rights-of-way. The capability to meet the goal is maintained by carrying out studies directed towards exploring novel concepts of vegetation control, attempting to improve on existing control techniques, providing environmental information, evaluating new products, and expanding the knowledge base of the cause of vegetation problems.

1984-

Novel approaches explored in 1984 were: the allelopathic potential of cover crops, and the influence of time of cutting on extent and rate of tree regrowth. In the former, aqueous extracts of grasses and legumes were screened for their ability to inhibit germination of the seeds of three woody species. Separate aqueous extracts were obtained from roots and aerial plant parts. Although germination inhibition was demonstrated, the results were inconsistent. Allelopathic responses were evident more frequently from extracts of aerial plant parts than roots. Studies on the influence of time of cutting on regrowth continued at the Wesleyville experimental plots and a new vegetated site was added next to an existing right-of-way at McCowan Road. These are both long-term studies due to the relatively slow growth of trees. Preliminary results from the Wesleyville site showed some evidence that trees cut from October to March produce more sprouts with higher growth rates than trees cut at other times of the year.

New substances evaluated in 1984 included Triclopyr, whose effectiveness in killing tree stumps was evaluated. Triclopyr was found to be extremely effective in killing three species of trees, while picloram plus 2,4-D and 2,4-D plus 2,4-DP were less effective in that order. Two concentrations of picloram plus 2,4-D or Triclopyr applied to the soil/roots of white and Carolina poplar were effective in killing the aerial portions of the trees. Herbicide content of roots coupled with long-term studies of the root systems at Wesleyville should demonstrate how

much herbicide is needed to kill the root system. The following growth regulators were evaluated, MBR 18337, EL-500 and PP333. All three growth regulators caused significant reduction in the growth of sprouts after injection into the trunks of two-year-old silver maple. The latter two were the more effective regulators.

An investigation of the movement of Tordon applied to the Des Joachim transmission corridor was initiated. Persistence in vegetation, and movement in soils are being monitored through the winter. Concentrations in fish and small mammals will be monitored. Early results showed that movement in the soil was still taking place two months following spraying, and small amounts were detected in the lake which bissected the transmission corridor.

A study was initiated at the McCowan site to determine the relative importance of tree stumps, young seedlings, seed bank, and aeolian invasion of seeds, in the establishment of problem species on a managed right-of-way.

1985-

Studies will continue in the areas of effects of time of cutting on sprout formation, and allelopathy. The stands of trees that have been cut during the past year will be monitored for the number of new sprouts being formed and their length. In the allelopathy study the source of the substances will be sought, as well as the influence of plant age on allelopathic substance production for selected plants will be determined.

The results of the investigations of EL-500 and PP333 will be expanded to field stands to determine long-term impact of growth regulators, as well as to get a better understanding of their mode of action. The Des Joachim study on movement of Tordon into lakes adjacent to the right-of-way will be completed, and if warranted an investigation of factors controlling movement into water bodies will be initiated to permit estimates of possible water contamination following application of the herbicide.

The McCowan site investigations on factors affecting succession on treated rights-of-ways will continue.

Contract Impingement Studies

A fish impingement program designed to develop fish exclusion schemes to keep fish out of generating stations' intakes was initiated at Ontario Hydro Research in 1978. At the time most available technologies were based on the physical exclusion of

fish. The concept put forth by the BRS was that it may be possible to use the normal behavioural responses of fish to selected stimuli to discourage them from entering the intakes. A series of studies on behavioural deterrents ensued with encouraging results. By 1980 most of the studies started to be funded by corporate clients wishing to have various behavioural schemes tested. Over the last two years most investigations in the behavioural exclusion areas have been carried out for and funded by clients from outside the corporation, ie CEA and ESEERCO.

In 1984 the 1983 ESEERCO contract was renewed with the objectives of: i) determine the numbers of acoustic poppers necessary to exclude alewife, ii) assess the fish mortality due to poppers in an fish exclusion design, iii) determine the responses of demersal species to poppers. The studies were successfully carried out with positive results.

CEA funded the first phase of a study to assess the potential of selected behavioural systems in guiding or diverting both upstream and downstream migrating fish at hydro-electric facilities. The study undertaken consisted of both field and laboratory components with emphasis on salmonid species. The results indicated that it was feasible to exclude fish from selected areas, as well as concentrating selected species for removal or passage as desired. The results were deemed sufficiently positive to warrant future studies at selected hydraulic sites.

1985-

In 1985 a renewal of the ESEERCO contract is expected. The focus of the 1985 studies will be on the testing of a simulated acoustic popper that is being developed by Ontario Hydro.

Phase two of the CEA-funded work to evaluate the most promising behavioural system at selected hydraulic sites will be sought.

The Biological Research Section has been selected by EPRI to carry out the field evaluation of behavioural fish exclusion systems for the Great Lakes portion of their fish protection program. The study will be carried out at the Pickering NGS test diversion structure.

Capitalized Once Through Cooling

In 1984 the Biological Research Section carried out two studies as part of Design and Development's Capitalized Once Through Cooling Program (COTC). These were a field investigation

to assess the potential offshore displacement of larval fish by thermal discharge plumes, and the development of a sonar "early warning" system to detect large schools of fish in the vicinity of intakes and activate diversion apparatus before a massive impingement occurs.

The offshore displacement study was conducted at Bruce NGS 'A' using radio transmitting drift tubes. Results indicate some offshore displacement, especially for tubes released near shore. The work on an "early warning" system carried out in 1984 consisted of the identification of suitable components and suppliers.

1985-

The electronic apparatus for the "early warning" system will be constructed; field testing with known fish targets will take place at the Lennox TGS forebay. If possible, testing at operating CCW intakes (probably Pickering NGS) will be attempted.

The offshore displacement study will continue; attempts will be made to assess the actual displacement patterns for naturally occurring alewife larvae.

A pilot system assembled for diverting and recovering entrapped fish from the Pickering NGS 'A' and 'B' forebays will be tested during the alewife and smelt runs.

Other Studies

Thermal Aquaculture - In 1984 studies were initiated to investigate the possibility of using electricity production byproducts to enhance the aquaculture industry in Ontario, and specifically attempt to develop a use for waste heat. The approaches taken were to assess the possibility of making thermal aquaculture a viable alternative to the conventional methods of raising rainbow trout over a limited portion of the year, and to attempt to develop a new unique aquaculture product for Ontario which would be dependent on waste heat.

During the year a study on the feasibility of producing fingerling trout for stocking purposes on a year-round basis was carried out. The concept investigated was the retardation and ultimate long-term control of hatching by means of temperature control. Results to date suggest that the concept is a viable one with successful hatching times being more than doubled.

In exploring new products, studies centered on developing techniques for the successful intensive culture of the Malaysian freshwater prawns at Canadian latitudes. The prawn is currently

successfully farmed in a number of tropical regions of the Pacific rim. They are tasty, highly productive, reach marketable size in about six months, and require 27°C water for optimal growth. On the negative side, there were some Canadian reports that they were highly cannibalistic. Through the year we maintained culture of the species, and gathered significant information on their habitat and food requirements, as well as gathering first-hand experience in maintaining the animals. Concurrently a graduate student was supported at the University of Western Ontario, who carried out a study to determine the physical feasibility of utilizing thermal effluents for freshwater shrimp culture. His results indicated that the optimum option is to use covered ponds which would require less than 0.1 m^3/s of 40°C water at the coldest time of the year, and no heat for four months of the year.

1985-

Most of the aquaculture effort in 1985 will be directed towards identifying and quantifying the factors which will make intensive culture of the Malaysian prawn feasible. Basically the thrusts will be in areas that will lead to the ability to grow large numbers of organisms under crowded conditions to fairly uniform marketable size over a brief period of growth. A study to identify the optimum diet for intensive growth will be carried out. Other factors to be investigated in depth are: the utilization of space, habitats which increase survival, and research to identify the sources of the highly variable sizes in the population.

Biofouling Studies - Investigations were carried out on the role played by films of living organisms in reducing heat transfer and flow in heat exchangers. One study focused on the susceptibility of stainless steel, admiralty brass, and titanium to biofouling. Stainless steel was the most susceptible to fouling and lost the greatest heat transfer efficiency; titanium developed the thinnest film, while brass lost the least heat transfer efficiency. A second study was undertaken to assess the biofouling potential inherent in the lake water supplies at Pickering (Lake Ontario), Bruce (Lake Huron), and Nanticoke (Lake Erie). Following 131 days of incubation in the laboratory it was concluded that Bruce NGS had the lowest potential for biofouling while the Erie and Ontario waters had the greatest.

1985-

Cooperative studies with the Metallurgy Department are anticipated to begin. These studies will look at the role of microbial organisms in enhancing or initiating corrosion of metal surfaces.

The concept of irradiating water as a means of controlling microbial growth will be investigated.

Acid Rain - A study to determine whether microbiological soil components have a role in buffering acid precipitation was carried out in the laboratory. It was concluded that although the presence of the biota did not appear to alter the acidity of the leachate it did influence positively those components related to plant production, and hence it was felt that the biota probably reduced the impact of acidification in soils.

1985-

The study on responses of benthic organisms to waters of different acidities will be completed, and an attempt to identify the factors related to the pH status of 200 Ontario lakes will be attempted.

OVERVIEW

This report has presented an overview of the activities undertaken by the Biological Research Section during 1984, and some projected activities for 1985. It was indicated in the Introduction that much of the present organization and activities are the results of a pattern established in 1978. Since that time the emphasis in the Corporation has changed from a supply-driven to demand-driven strategies. Slower growth environment has resulted in a lowering in demand for environmental survey type activities, and to some extent environmental protection.

The Biological Research Section has responded by redirecting its efforts into areas which may create opportunities to increase effectiveness and efficiency for the Corporation, such as vegetation control, fish impingement, and tritium removal by biological catalysis. Opportunities for revenues in areas of interest to the Corporation have been sought by marketing areas of expertise that are of interest to others such as fish impingement mitigation, and environmental radiobiological studies. Opportunities for sale of steam or waste heat, as well as developing a new industry for Ontario, are being attempted through the thermal aquaculture research.

The redirection of the Biological Research Section will result in some organizational changes. At present the organization of the section is based primarily on supporting the corporate environmental survey needs. The changes will insure that the environmental needs be met, but will also increase the flexibility required for the search of novel opportunities. This will be attained by moving more into a program management mode while maintaining rigid structures only in areas where a demand for long-term capability exists.

Technologies in which we are attempting to develop expertise and that we think will have significant future impacts are biotechnology and remote sensing. In the former expertise is being developed through the studies on tritium removal by biological catalysis and the thermal aquaculture work. Remote sensing capability will be developed with the objective of finding quick, inexpensive, and reliable means of carrying out large scale environmental surveys. This capability will be developed by redeploying people currently involved in the impingement program.

Areas of future potential concern to Ontario Hydro which are being monitored but in which no formal research activities have been initiated are: acid effects on forests, and biological environmental effects.

Approved by:

O.A. Kupcis
Manager
Chemical Research Department

Prepared by:

G.L. Vascotto
Supervising Biologist
Biological Research Section

GLV:rv

APPENDIX A

1984 Staff List

Supervising Biologist-	
Dr. G.L. Vascotto	
Section Secretary-	
Ms. C. Goto	
Section Assistant-	
Ms. R. Nakrosius	
Unit Head Field Oriented Research-	
Mr. G.T. Haymes (Biological Surveys Coordinator)	biological surveys, bird biology, field impingement tests
Researchers-	
Mr. H. Balesic	biological surveys, acoustic fish census
Mr. W.E. Carey	biological surveys, fisheries
Mr. R.W. Sheehan	biological surveys, field techniques
Technical Staff	
Mr. L. King	
Mr. D. Lowther	
Mr. L. Onisto	
Mr. O. Turczyn	
Unit Head Resources and Services Unit-	
Mr. R.S. McKinley	radionuclides in sediments, biofouling, movements of herbicides
Researchers-	
Ms. J.K. Kwik	prawn aquaculture, zooplankton
Dr. D.W. Rogders	radionuclides in fish and sediments, fish removal techniques, fish physiology
Supervising Technician-	
Mr. D.J. Parker	
Technical Staff-	
Mr. P. Atkins	
Ms. J. Battrick	
Mr. E. Checko	

Technical Staff (contd)-
Mr. J. Harcus
Mr. H. Kowalyk
Mr. G. Murphy
Mr. P. Niklas
Mr. B. Sim
Mr. F. Stubbs
Ms. L. Vereecken-Sheehan

Unit Head Fundamental Research-	
Dr. G.L. Vascotto	benthic biology, aquatic ecology, biostatistics, acid rain effects
Researchers-	
Dr. G.P. Arron (Vegetation Control Coordinator)	vegetation control, plant biochemistry
Mr. T.G. Dunstall	tritium in soils, biological catalysis, entrainment
Dr. J.S. Griffiths (COTC Coordinator)	intake technologies, fish impingement, fish physiology
Ms. M. Kirby	vegetation control, aquatic vegetation, statistics
Dr. P.H. Patrick (Impingement Contract Coordinator)	fish impingement, bioenergetics
Dr. V.J. Sharpe	biofouling, acidification of soils
Dr. F.S. Spencer (Radiobiology Coordinator)	tritium dynamics, vegetation control, plant biochemistry

APPENDIX B

Reports Issued in 1984

Report No.	Description	Author	Client
84-19-K	Effects of Aqueous Effects of Cover Crops on the Germination of Seeds of Black Spruce (Picea mariana) and White Spruce (P. glauca)	G.P. Arron	Research
84-47-K	BNPD 1979-1981 Post Operational Aquatic Studies Summary	W.C. Carey	Design & Develop.
84-55-K	Phytotoxic Effects of the Herbicides ...in a Cucumber Seed Bioassay	G.P. Arron	Research
84-56-K	A Review to Assess the Possibility of Thermal Aquaculture of Crustaceans	J.K. Kwik	Design & Develop.
84-79-K	Laboratory Studies of Fish Response to CCW Intakes - 1981	J.S. Griffiths	Design & Develop.
84-111-K	Influence of Water Current and Wave Action on Substrate Selection by Larval Round Whitefish	R.S. McKinley	Design & Develop.
84-135-K	Pickering GS 'B' Preoperational Biological Study Summary Report 1979-1982	J.K. Kwik	Design & Develop.
84-144-K	Mississagi River Bank Stabilization Program Aquatic Monitoring 1983	R.W. Sheehan	Design & Develop.
84-149-K	Laboratory Studies of Fish Diversion by Louvre Guidance Systems	J.S. Griffiths	Design & Develop.
84-150-K	Effectiveness of a Hidrostal Pump in the Live Transfer of American Eels	P.H. Patrick	Transmission
84-165-K	Susceptibility of Different Metal Surfaces to Biofouling	R.S. McKinley	Research
84-207-K	Laboratory Studies of Fish Capture Efficiency of Cone-Shaped Intake Structures	D.W. Rodgers	Design & Develop.
84-217-K	Dynamics of Tritium Accumulation in Juvenile Rainbow Trout, Salmo gairdneri, exposed to Tritiated Water, Tritiated Diet or Both	D.W. Rodgers	Research

APPENDIX B (Continued)

Reports Issued in 1984

84-254-K	Microbiological and Chemical Equilibria in Acid Stressed Soils	V.J. Sharpe	Research
84-276-K	Microbial Speciation and Biofouling Potential of Cooling Water Used by Ontario Hydro	D.W. Rodgers	Research
84-290-K	Hydrogen Metabolism...Fission Technologies	T.G. Dunstall	Research
84-310-K	A Field Study of the ... Direct Fish	W.E. Carey	Design & Develop.
84-319-K	Effect of Trunk Injection of the Growth... Silver Maple	G.P. Arron	Research
84-341-K	Pickering NGS 'B' Interim Aquatic Study 1983	W.E. Carey	Design & Develop.
84-432-K	Responses of Fish Common to the Atikokan Lakes Area to Various Deterrent Devices - 1984	P.H. Patrick	Design & Develop.
84-458-K	Effects of Components of Macrobrachium rosenbergii Aquaculture Practices on their Productivity.	J.K. Kwik	Research
C84-9-K	Microbiological Examination of a Lube Oil Heat Exchanger at Bruce NGS 'A'	V.J. Sharpe	CNS
C84-26-K	Comparison of a Free-flowing and Normal Popper in Repelling Fish	G.T. Haynes	Design & Develop.
C84-30-K	Filtered Mercury Vapour Light Tests at Lambton TGS During November, 1983	L.P. King	Design & Develop.
C84-40-K	Microbiological Examination of Lakeview TGS Domestic Water	V.J. Sharpe	CTS
C84-44-K	Herbicide Content of Water Samples Collected in 1983 Near the Herbicide Study Area, Wesleyville GS	G.P. Arron	Research
C84-60-K	Conference Report - Futures in Water Toronto, June 12-14, 1984	G.T. Haynes	Research
C84-86-K	McCowan Road ROW Study Preclearing Conditions	M.K. Kirby	Research

APPENDIX B (Concluded)

Reports Issued in 1984

C84-111-K	Microbial Hydrogen Metabolism	T.G. Dunstall	Research
C84-115-K	Field Experiments on Sprout ... A Preliminary Report	G.P. Arron	Research
CFFTP	Elemental Tritium Deposition and Conversion	F.S. Spencer	Research

APPENDIX C

List of Publications by Biological Research Section Staff in 1984

Author	Title	Journal	Pub Info
D.W. Rodgers	Ambient pH and Calcium Concentration on Growth and Calcium Dynamics of Brook Trout. Salvelinus fontinalis	Canadian Journal of Fisheries and Aquatic Sciences	
D.W. Rodgers	Tritium Dynamics in Rainbow Trout	American Zoologist	1984 24(3). pp 112A
P.H. Patrick and B. Sim	Effectiveness of a Hidrostal Pump in the Live Transfer of American Eels	Hydrobiologia	1985 The Netherlands (not yet published)
P.H. Patrick A.E. Christie D. Sager C. Hocutt J. Stauffer Jr.	Response of Fish to a Strobe Light/Air Bubble Barrier	Fisheries Research Journal	1985 (not yet accepted).
T.G. Dunstall	Tritiated Water Uptake and Desorption Kinetics in a Primary Producer: Chlorella pyrenoidosa	Water Pollution Research Jrnl of Canada	Vol 19. No 1. 1984
T.G. Dunstall G.T. Haymes & J.K. Kwik	Influence of a Thermal Electric Generating Station on Water Chemistry and Distribution of Plankton	Journal of Great Lakes Research	1985 (not yet published
T.G. Dunstall	Distribution of Rainbow Smelt and Alewife Larvae Along the North Shore of Lake Ontario	Journal of Great Lakes	Vol 10. No 3. 1984. pp 273-279
G.T. Haymes & D.P. Kolenosky (Ontario Ministry of Natural Resources)	Distribution and Characteristics of Spawning Round Whitefish in Lake Ontario 1976-1981	Ontario Fisheries Technical Report Series	
G.T. Haymes & R.W. Sheehan	Winter Waterfowl Around Pickering Nuclear Generating Station	Canadian Field Naturalist	Vol 96. pp 172-175. 1982
G.T. Haymes. & L.J. Onisto	Attraction of Fish to Mercury Vapour Generating Station Forebay	International Revue Hydrobiol.	Vol 69. pp 867-876

APPENDIX D

List of Conference Papers Presented by Biological Research Section Staff in 1984

Author	Title	Conference	Date/Place
T.G. Dunstall	Tritium Oxide Uptake and Desorption Kinetics in a Primary Producer: Chlorella pyrenoidosa	Nineteenth Canadian Symposium on Water Pollution Research	CCIW, Burlington, Ont February 23, 1984
G.T. Haymes	Effectiveness of Filtered Mercury Vapour Lights to Attract and Lead Fish in a Generating Station Forebay	27th Conference on Great Lakes Research	Brock University, St. Catharines, Ontario, April 30, 1984
P.H. Patrick	Fish Impingement at Ontario Hydro's Generating Stations	EPRI Workshop on Fish Compensatory Mechanisms	Airlie, Virginia, August 26, 1984
P.H. Patrick	Summaries of Ontario Hydro's Fish Impingement Program and Research Involving Sound as a Deterrent	CEA Workshop on Alternative Fish Protection Schemes	Toronto, Ontario, September 17, 1984
P.H. Patrick	Fish Protection Schemes	Joint Power Generation Conference	Toronto, Ontario September 30-October 4, 1984
D.W. Rodgers	Tritium Dynamics in Rainbow Trout	American Society of Zoologists	Denver, Colorado, USA December 27-30, 1984
R.W. Sheehan	Effectiveness of a Rope Net Barrier in Excluding Fish	27th Conference on Great Lakes Research	Brock University, St. Catharines, Ontario April 30, 1984

APPENDIX E

List of Contracts Awarded to Biological Research Section in 1984

Department	Funded by	Title	Amount
Chemical (P.H. Patrick)	CEA	Fish Behaviour - Hydroelectric Facilities	93 000
Chemical (P.H. Patrick)	ESEERCO	Alternative Fish Protection Techniques	190 000
Chemical (F.S. Spencer)	CFFTP (cofunded OHRD & CFFTP)	Elemental Tritium Deposition and Conversion	109 000 (CFFTP portion)